(B1304) Combining High Resolution HICO and GOCI Imagery With Ocean Circulation Models: Towards a Fully-3D Advection-Diffusion-Reaction Forecast Capability

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Sherwin D. Ladner[1], Jason Jolliff[1], Robert Arnone[1], Richard W. Gould, Jr.[1], Clark Rowley[1], David Lewis[1], Brandon Casey[2], Paul Marinolich[2]

(1) Naval Research Laboratory, Code 7330, Stennis Space Center, MS 39529 (USA), (228) 688-5754, ladner@nrlssc.navy.mil (2) QinetiQ North America, Stennis Space Center, MS 39529 (USA)

I. ABSTRACT

We present an ocean forecast model "BioCast" to forecast surface bio-optical properties derived from satellite via a coupling to numerical ocean model velocity fields. Surface bio-optical products derived from remote sensing ocean color platforms are used for defining water quality conditions on different spatial scales. For this study, we demonstrate this surface optical property forecast capability at 100m and 500m scales using data from the Hyperspectral Imager for the Coastal Ocean (HICO) and the Geostationary Ocean Color Imager (GOCI). The BioCast system initially treats surface optical properties derived from satellite as passive tracers for a simplified advection-diffusion scheme. At very high spatial/temporal resolution, we employ hindcast mode to better constrain particle source/sink terms of optically active constituents, particularly suspended sediments, in coastal environments. Hourly sequential GOCI products enable difference fields between BioCast forecast simulations and imagery to suggest potential timescales of sediment processes as well as potential areas where the flow fields might require adjustment. These observations will direct research toward the development of a self-correcting advection-diffusion-reaction forecasting system.

II. OBJECTIVES

- Demonstrate a high resolution surface optical forecast capability at 100m and 500m spatial scales using HICO and GOCI imagery.
- Compare modeled GOCI backscattering (bb) forecasts (initialized with hour 0) to observed hourly GOCI images to assess forecast skill and areas where source/sink terms and flow fields might require adjustment.

III. BACKGROUND

A. Satellites

Hyperspectral Imager for the Coastal Ocean (HICO) is a high resolution (100m) hyperspectral (128 bands) sensor developed by NRL that is currently deployed on the International Space Station's (ISS) Japanese Experimental Module – Exposed Facility. HICO was launched on September 11, 2009. The HICO hyperspectral bands were convolved to simulate the 9 MODIS bands. Band set (nm) = 412, 443, 488, 531, 547, 667, 678, 748 and 869.

Geostationary Ocean Color Imager (GOCI) is a high resolution (500m) geostationary multispectral (8 visible-to-near-infrared bands) sensor developed by Korea Ocean Research and Development Institute (KORDI) and is deployed onboard the Communication, Ocean, and Meteorological Satellite (COMS). It is the first and only geostationary ocean color sensor. The GOCI sensor images the Korean Sea daily for 8 hours at a time step of 1 hour with an aerial coverage of 2500km x 2500km. GOCI was launched on June 26, 2010. Band set (nm) = 412, 443, 490, 555, 660, 680, 745, and 865.

Optical backscattering (bb) was derived using NRL's Automated Processing System (APS) using the Quasi-Analytical Algorithm (QAA). APS automatically processes satellite imagery and generates map-projected image data bases of ocean color products from satellite data. The Gordon/Wang atmospheric correction with a NIR iteration and absorbing aerosol correction (Stumpf) was applied.

B. Model Flow Fields

Navy Coastal Ocean Model (NCOM) is atmospherically forced by the Navy Coupled Ocean and Atmospheric Mesoscale Prediction System (COAMPS). The NCOM model has 40 sigma depth layers. Regional nest at 500m (Chesapeake Bay) and 3Km (Western Pacific) resolution were developed within global NCOM using RELO-NCOM. Physical data is assimilated through the NRL Coupled Ocean Data Assimilation System (NCODA).

C. Advection Model

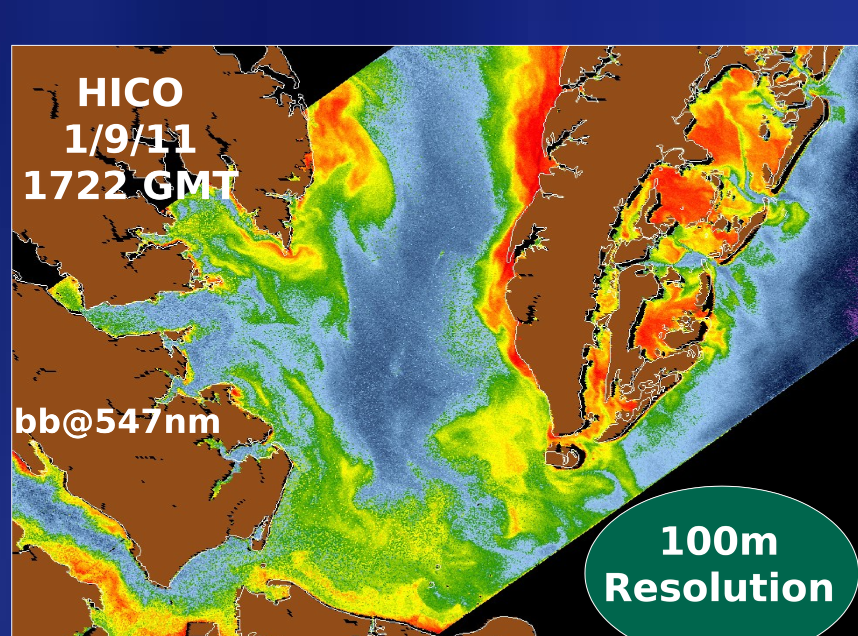
BioCast is a 3D ocean advection model developed at NRL (Jolliff). The model initially treats surface optical properties derived from satellite as passive tracers for a simplified advection-diffusion scheme via a coupling to ocean numerical model flow fields.

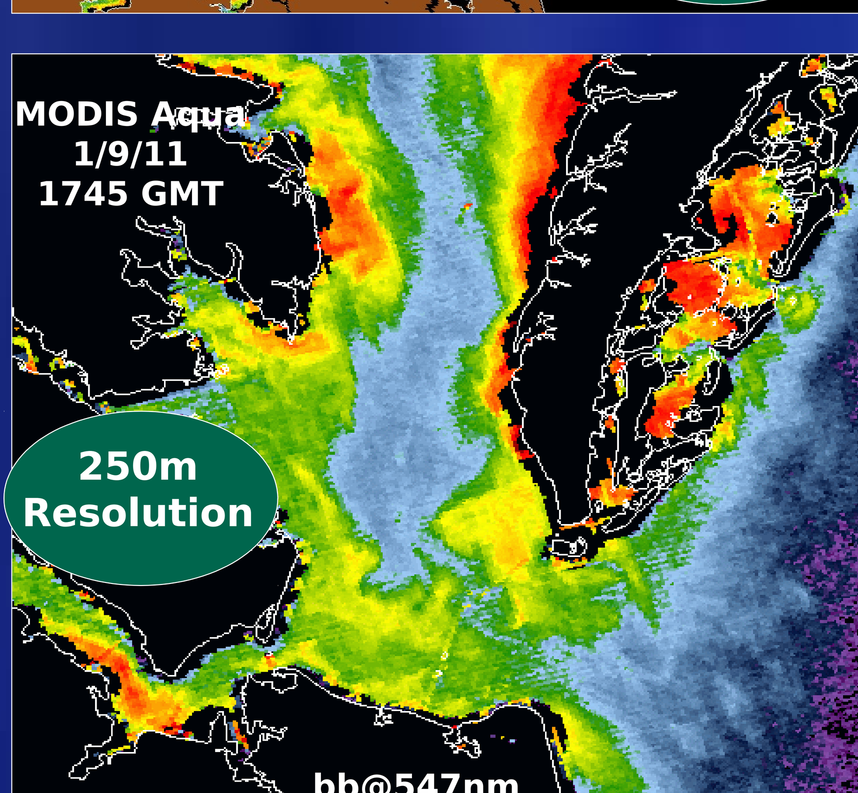
Inputs: 3D ocean numerical model flow fields , satellite surface/seed image, bathymetry
Output: Passive tracer advection @ temporal resolution of model input

Operational Flow:

1. Adjust model flow fields to obey continuity and Courant-Friedrichs-Lewy (CFL) stability over the user defined 3D grid and time step: [maximum horizontal velocity (m/s) * timestep (s)] / minimum dx or dy (m)
2. Check adjusted flow fields for stability
3. Define initial 3D tracer field (satellite surface image extended vertically - homogeneous)
4. Correct tracer field by adding sources and sinks (Future).
5. Advect tracer in 3D space using first order upwind differencing scheme
   Repeat steps 1-4 at time and resolution of physical model

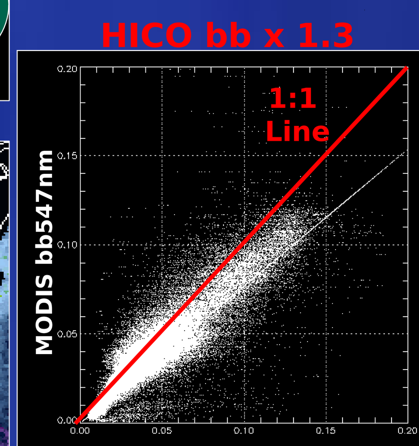
IV. HICO / MODIS BLENDED IMAGE (Backscattering @547nm) 1/9/11 (Initialization Optical Field SEED -> Advection Model -> 24 Hour Forecast)



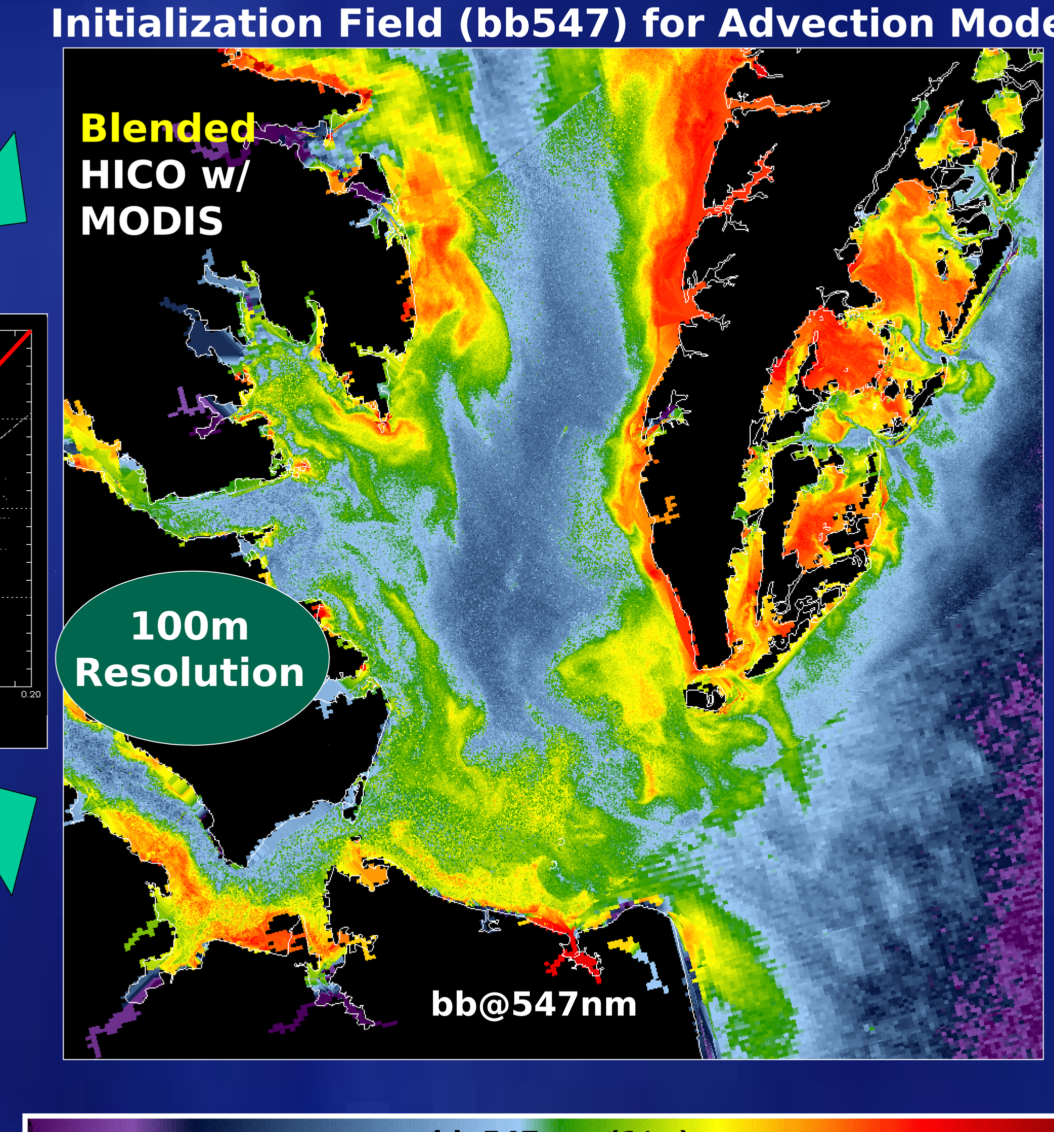


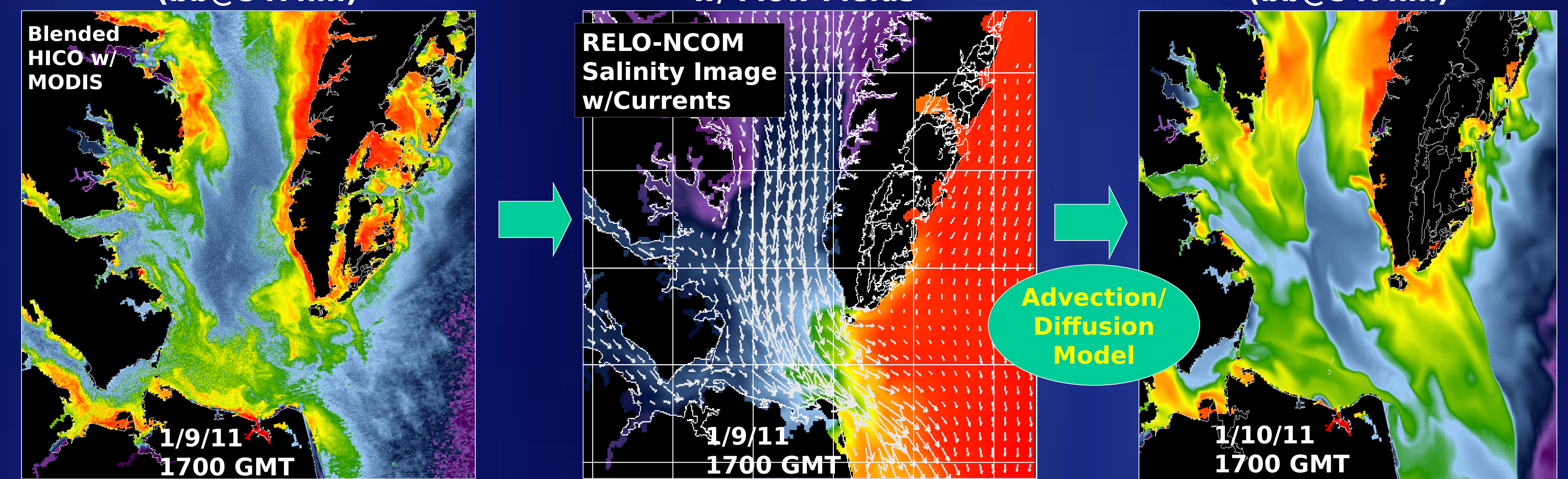
Derived backscattering (bb) from HICO and MODIS agree very well!

HICO bb x 1.3



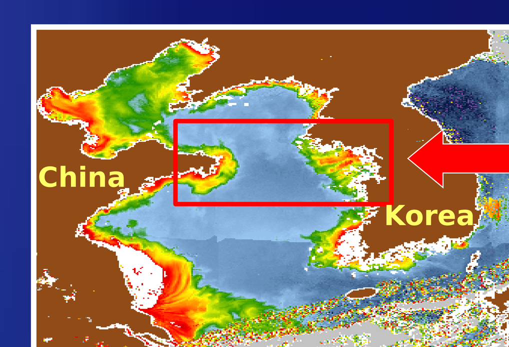
Initialization Field (bb547) for Advection Model





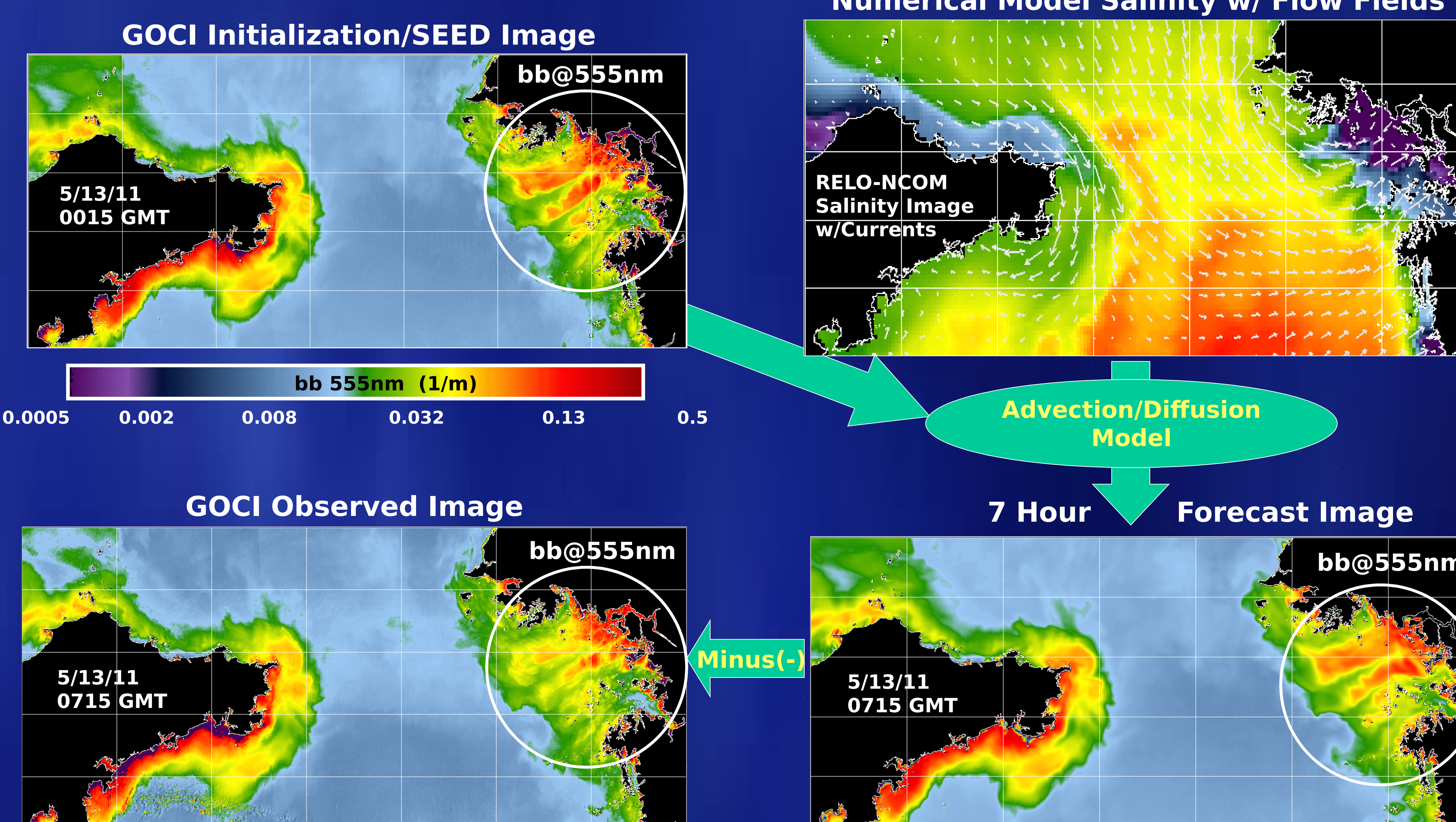
V. GOCI Backscattering @ 555nm 500m Resolution (Forecast Validation) Observed (Satellite) vs. Forecast

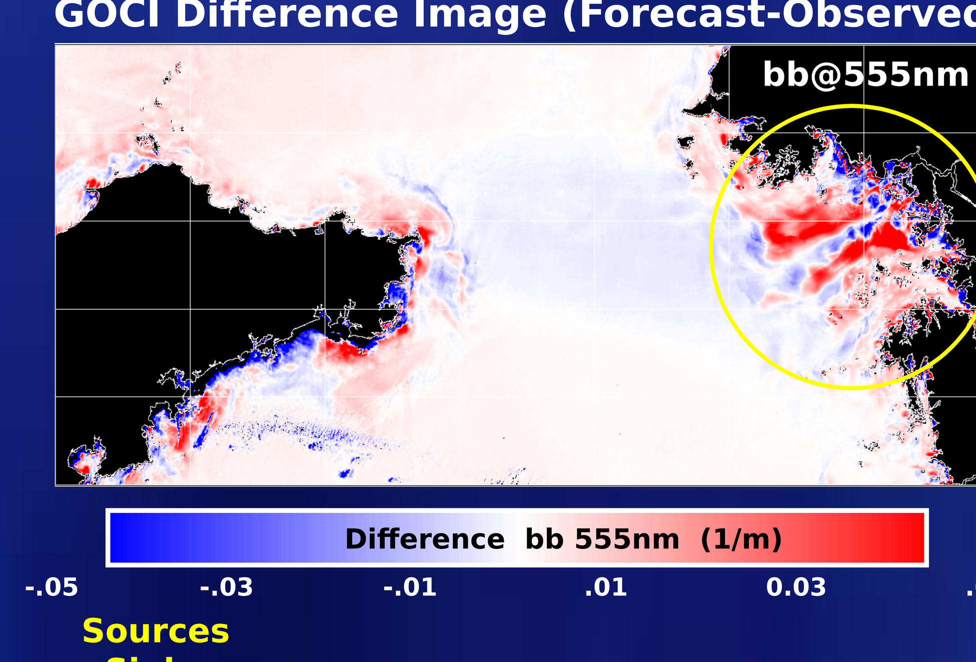
7 Hours @ 1 Hourly Time Steps - Korean Sea – 5/13/2011



GOCI Images were de-trended to minimize BRDF effects in the optical backscattering images due to change in solar angle:

De-trended Image = $(\text{Image}_n - \text{Mean}_n) + \text{MAX}(\text{Mean}_{0\text{-}7})$





Advection Model: Self-correcting Source & Sink / Flow Field Adjustment (Sediment Processes)

Table. Forecast Skill (bb@555nm)

Hour (GMT)	Mean Absolute Difference	Mean Absolute %Change
01	0.0044	12.1401
02	0.0058	16.7686
03	0.0066	20.4651
04	0.0069	21.0338
05	0.0069	22.1778
06	0.0070	22.8644
07	0.0070	25.2535

VII. SUMMARY

- Blended mutli-resolution HICO(100m) and MODIS Aqua(250m) backscattering at 547nm images to generate initialization tracer field for input into advection model (both sensors yielded similar values of bb)
- Produced forecasts of backscattering (bb@547nm) for HICO (24 hour) and GOCI (7 hour) by coupling high resolution ocean color imagery and a numerical model using a 3D advection/diffusion forecast model (BioCast)
- For GOCI, we compared the forecasts to observed bb@555nm concentrations (satellite) and assessed differences (Forecast Image – Observed Satellite Image). Hourly mean absolute differences ranged from 0.0044 to 0.0070 m^{-1} and increased with time for the 7 hour bb@555nm image sequence. For the majority of the image region, the advection model performed very well. The mean absolute % change ranged from 12.14% to 25.25% and increased with time over entire image. Initial forecast skill assessment indicates differences are attributed to sources & sinks.
- Differences in the GOCI forecast images will be linked with the advection model flow fields and sources/sinks to develop a self-correcting advection-diffusion-reaction forecasting system.

VIII. ACKNOWLEDGEMENTS

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Thanks to KORDI and GOCI Team for Imagery